

Lesson 5 (+)
Advanced Training
ECG, Eye Tracking, Power Injector

Lesson 5 (+)

Administrative Issues and Procedures

Safety Issues

Scanning Procedures

Data and Image Transfer

Scan Room Peripheral Equipment

Scan Room Issues

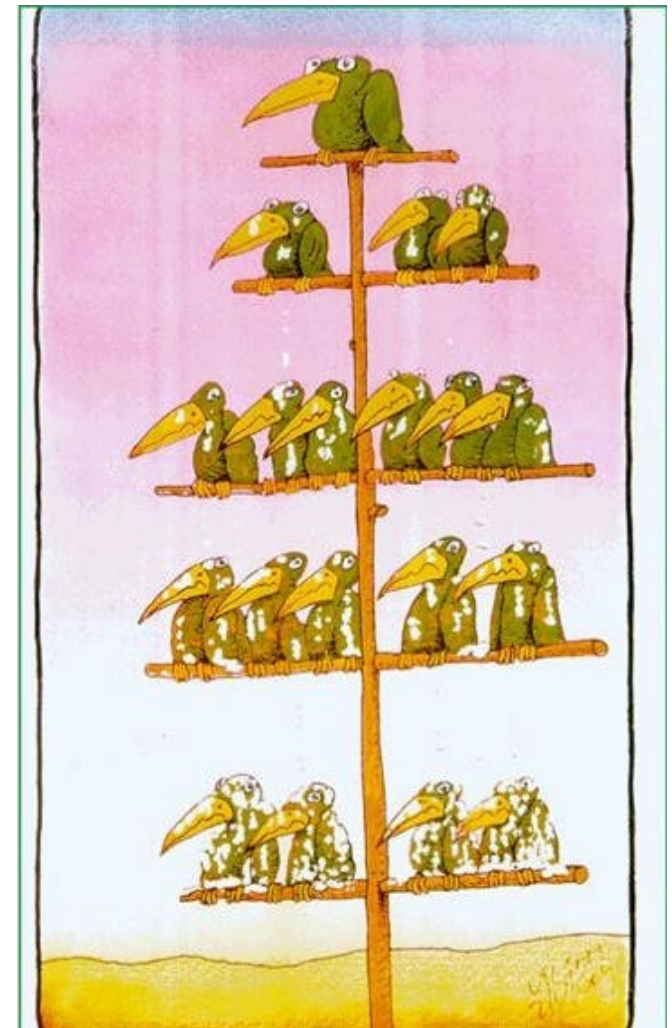
Miscellaneous

Advanced Training

Eye tracking

ECG Gating and triggering

Power Injector



ECG Specific Information

- Needs true “hands on” sessions in addition to presentation
- Please make appointment for more detailed information

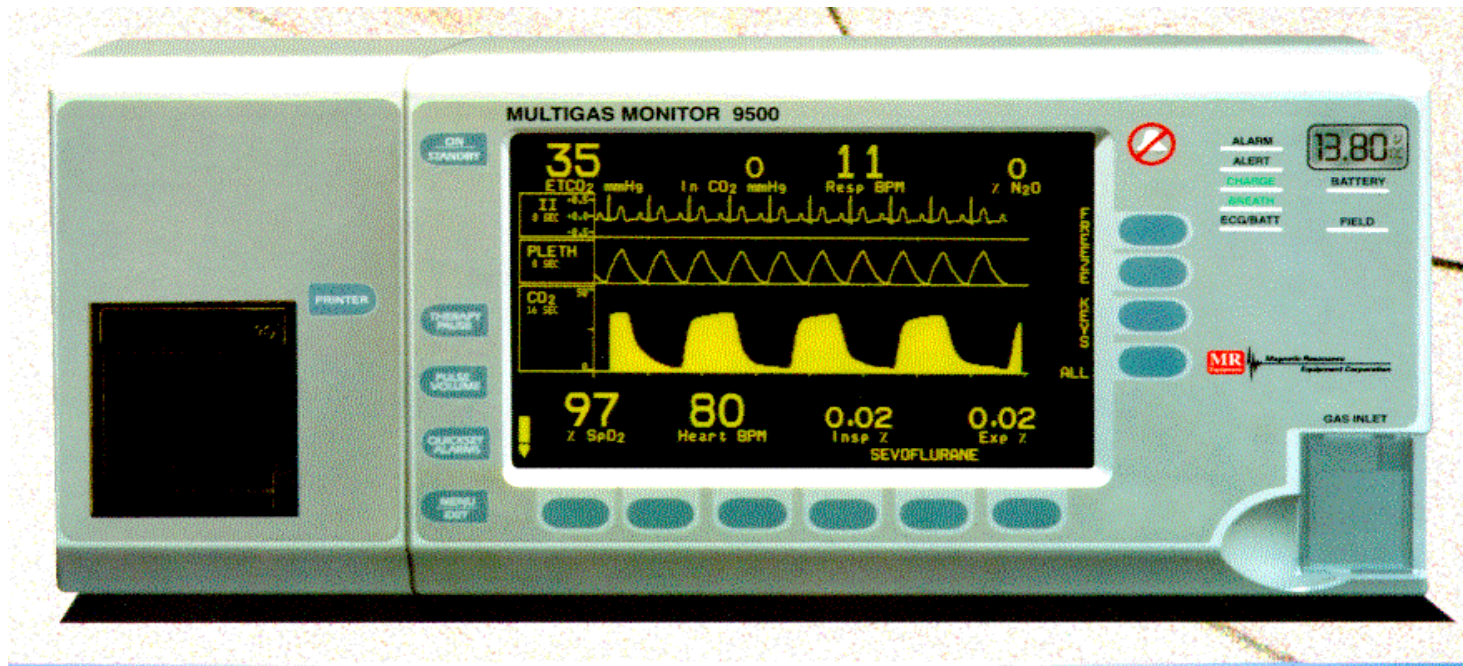
Types of MR Gating Equipment

- Fiber-Optic
- High Impedance
- High Impedance Fiber-coated

Examples of ECG Gating Problems

- Real arrhythmias (PVC's)
- Sinus arrhythmia
- Noise associated with breathing/breath-holding
- Missed triggers
- False positive triggers
- Gradient interference
- Wrong part of QRS complex trigger(T-wave)

The Medrad 9500 ECG Monitor



- Fiber Optic
 - Pulse Oximetry
 - NIBP
 - End-Tidal CO2
 - Anesthesia Capabilities

The Medrad ECG Monitoring System



The Main Monitor

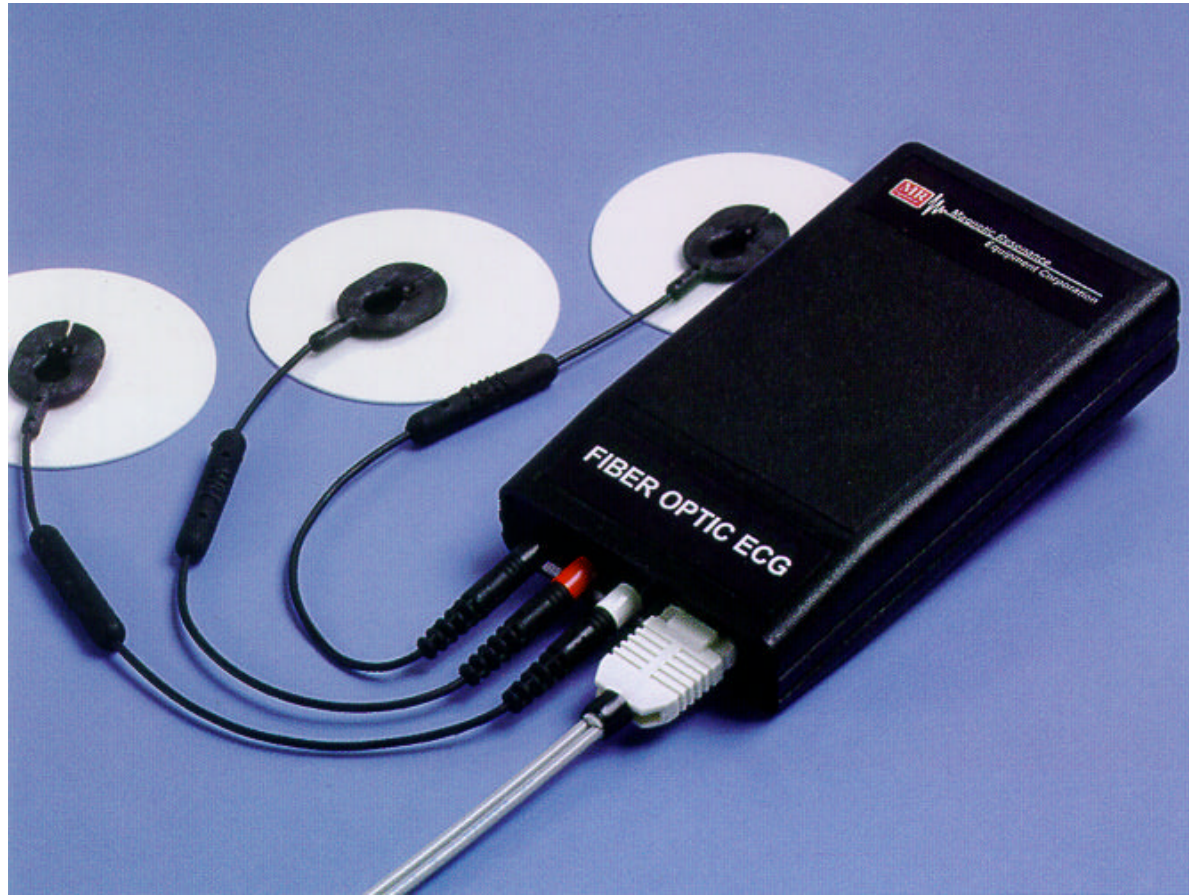
The Fox Module



The ECG Box_Shroud

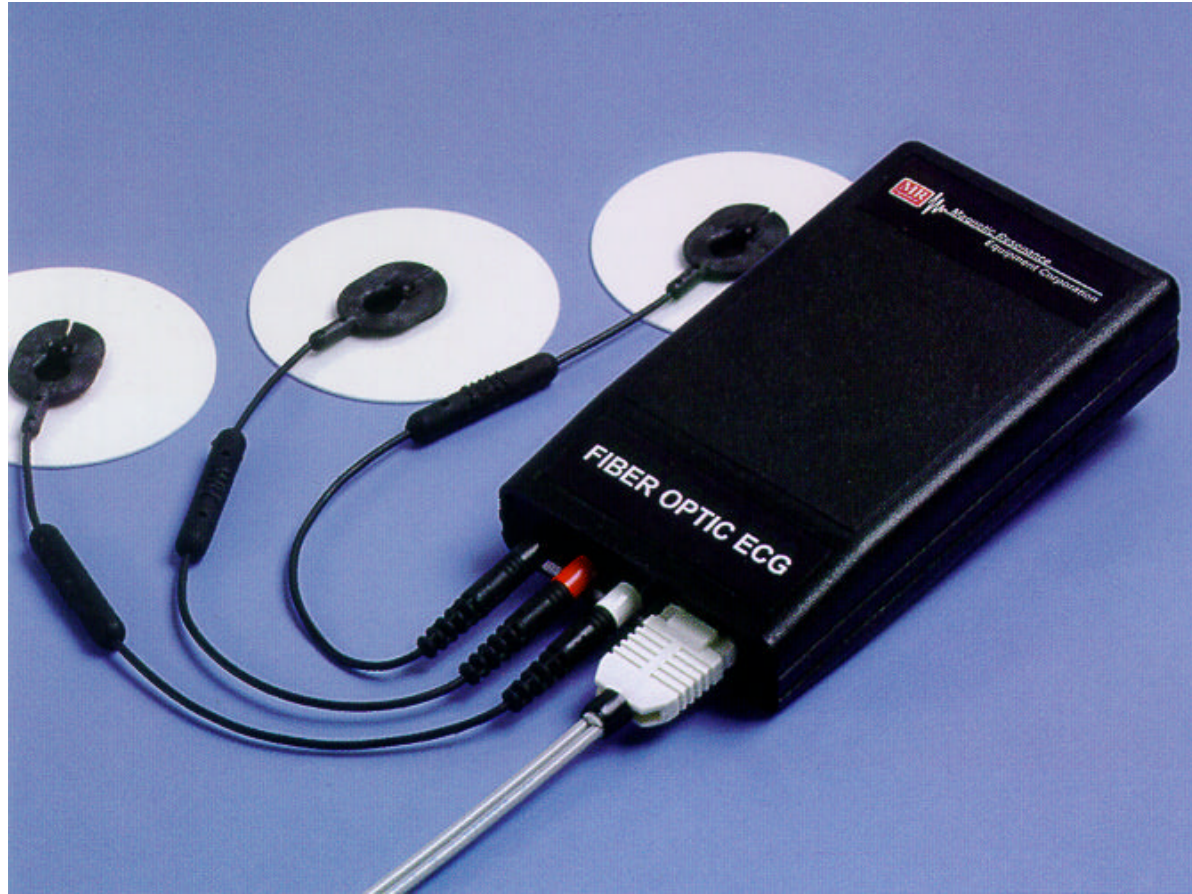
The Remote Monitor

The Medrad Fox Module



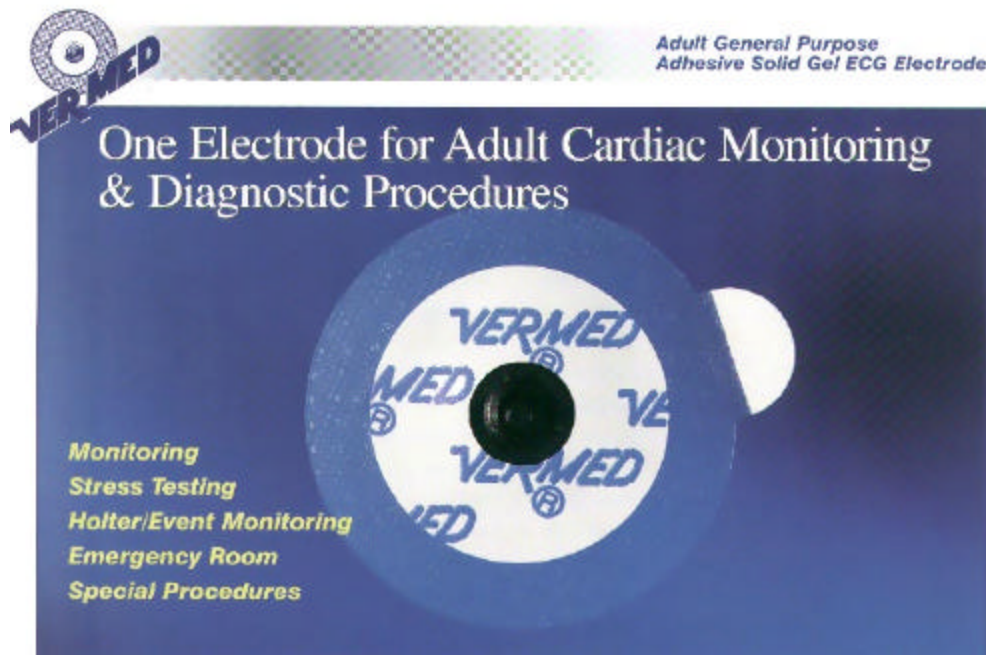
- Attach to the patient electrodes
 - On/Off switch on the side

The Medrad Fox Module



- Regular
- T-Wave
Suppressor
- Turbo Fox

Patient Electrodes



- Vermed Electrodes are stocked in the 3T and Cardiac Scanners
- Do NOT use the GE or 3M Electrodes
 - Metal nub

ECG Gating Control Window

GATING CONTROL

Waveform Display

☐ Cardiac

ECG Noise Filter: ☐ OFF

Advanced ECG Gating: ☒ ON

☐ Respiratory

☐ ECG Histogram

Cardiac Sweep Rate

☐ 10mm/sec

☐ 21mm/sec

☒ 41mm/sec

Gating Reset

Lead Display

☒ ECG-I

☒ ECG-II

☒ ECG-III

☒ PG

☒ Auto

Cardiac Trigger Level

☐ 50%

☐ 60%

☐ 70%

☒ Auto

Trigger Level: %

Update

R-peak Amp. mV

Cardiac Trigger Level Annotation: ☐ OFF

Audio Trigger Volume: 5

Accept

- This is the Default setting
 - Click on appropriate settings for gating or pulse oximetry

Cardiac Conducting System

- **Sinoatrial node**

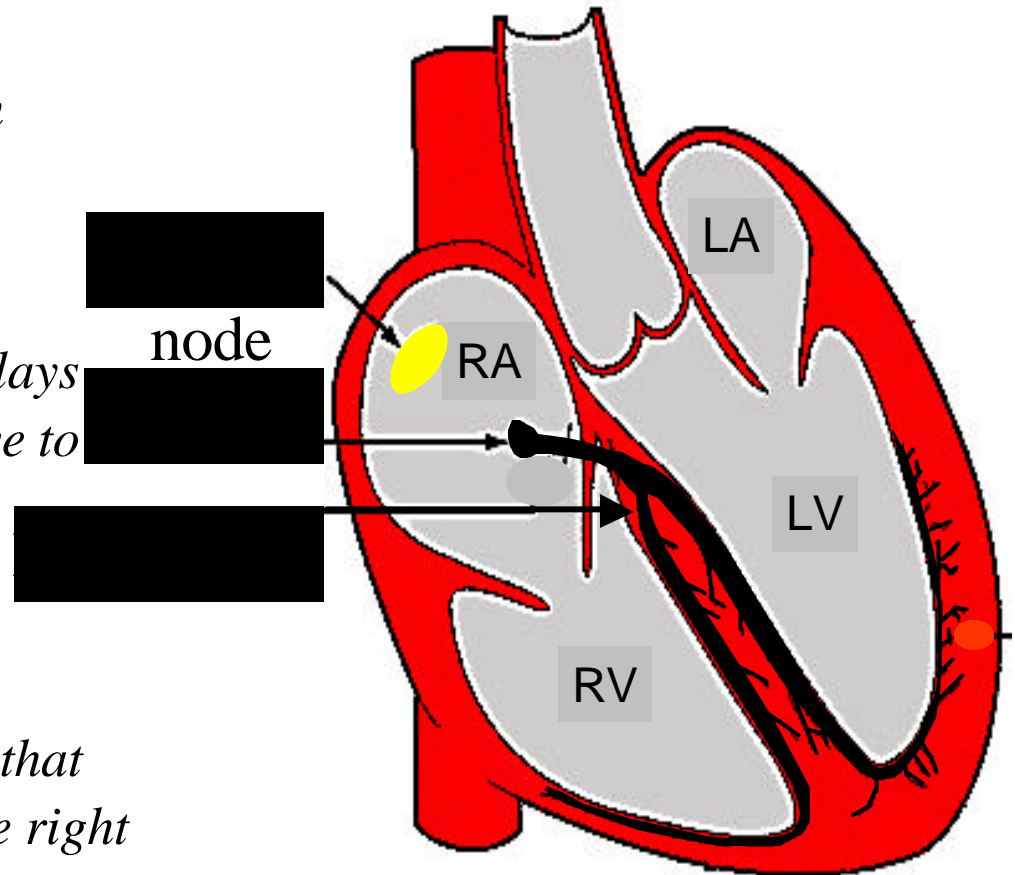
Origin of normal sinus rhythm

- **Atrioventricular node**

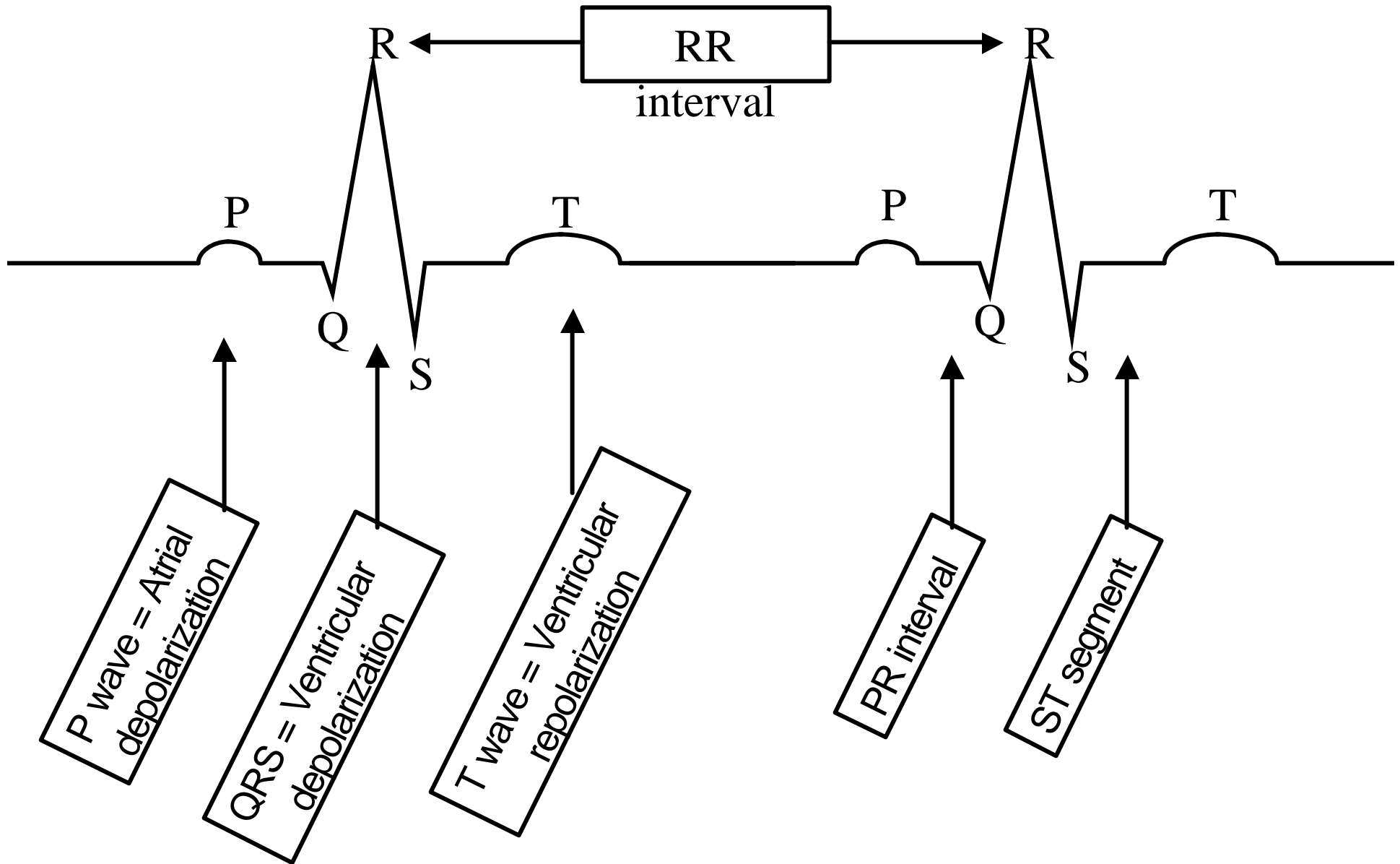
A conducting pathway that delays ventricular contraction relative to atrial contraction

- **His-Purkinje System**

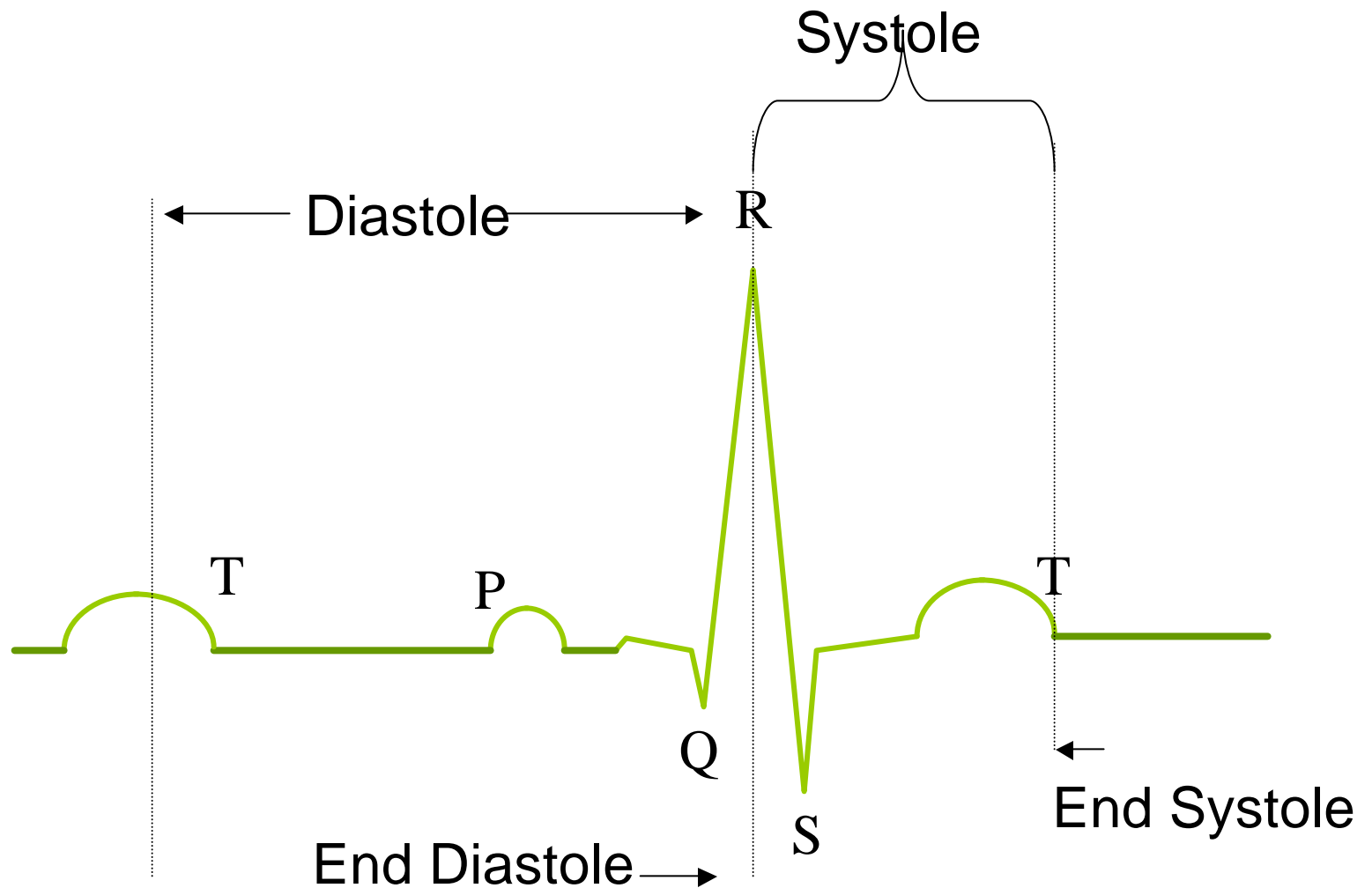
Rapidly conducting pathways that allow uniform excitation of the right and left ventricles



Components of the ECG Waveform



The ECG Signal



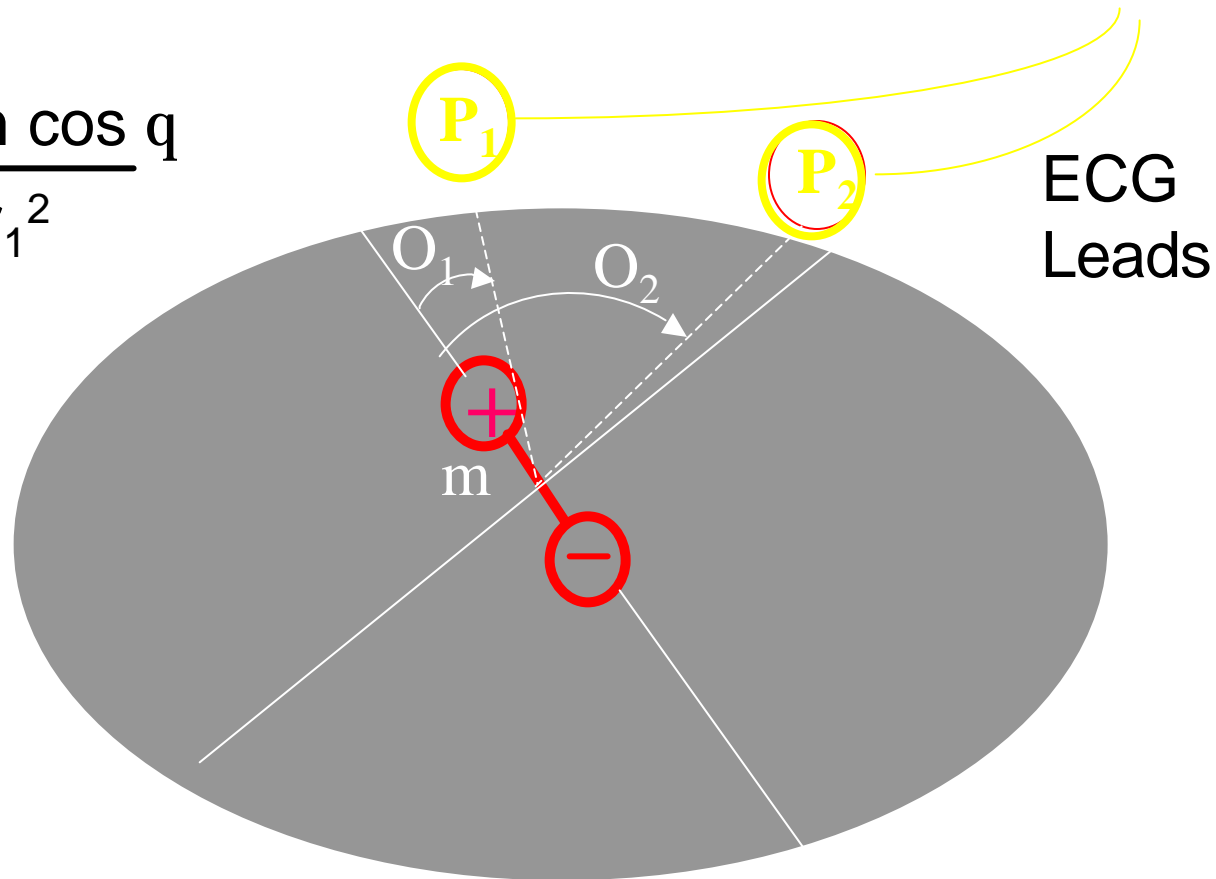
Delays Associated with ECG Triggers

- Electronic delays
 - Analog and digital filter delays
 - Serial devices
- QRS related delays
 - Trigger location relative to the QRS complex morphology.
 - LBBB, RBBB, IVCD
- Gating algorithm delays
 - slope detection
 - peak detection

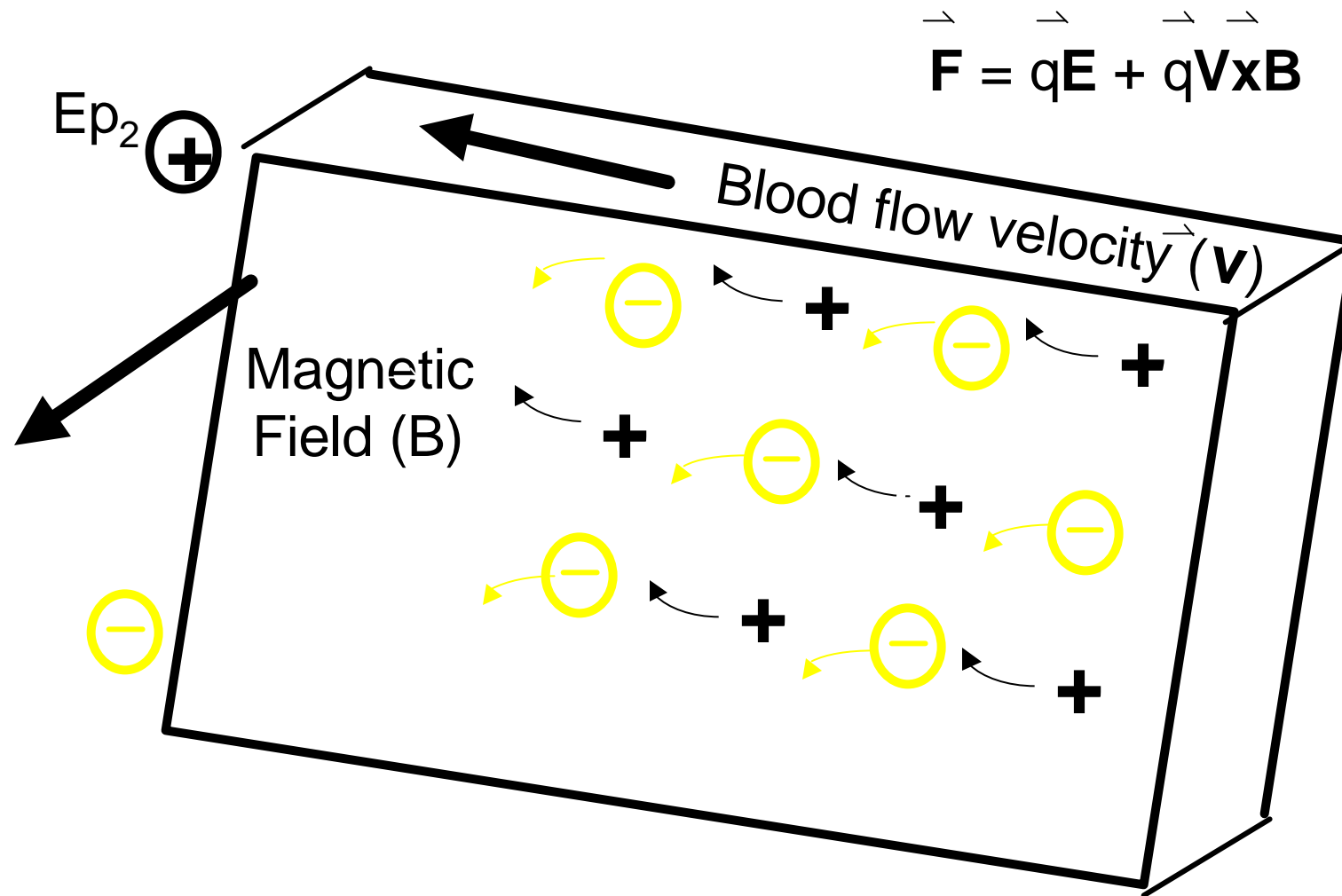


The ECG records the electric potential (E_p) from net dipole (m) of the heart

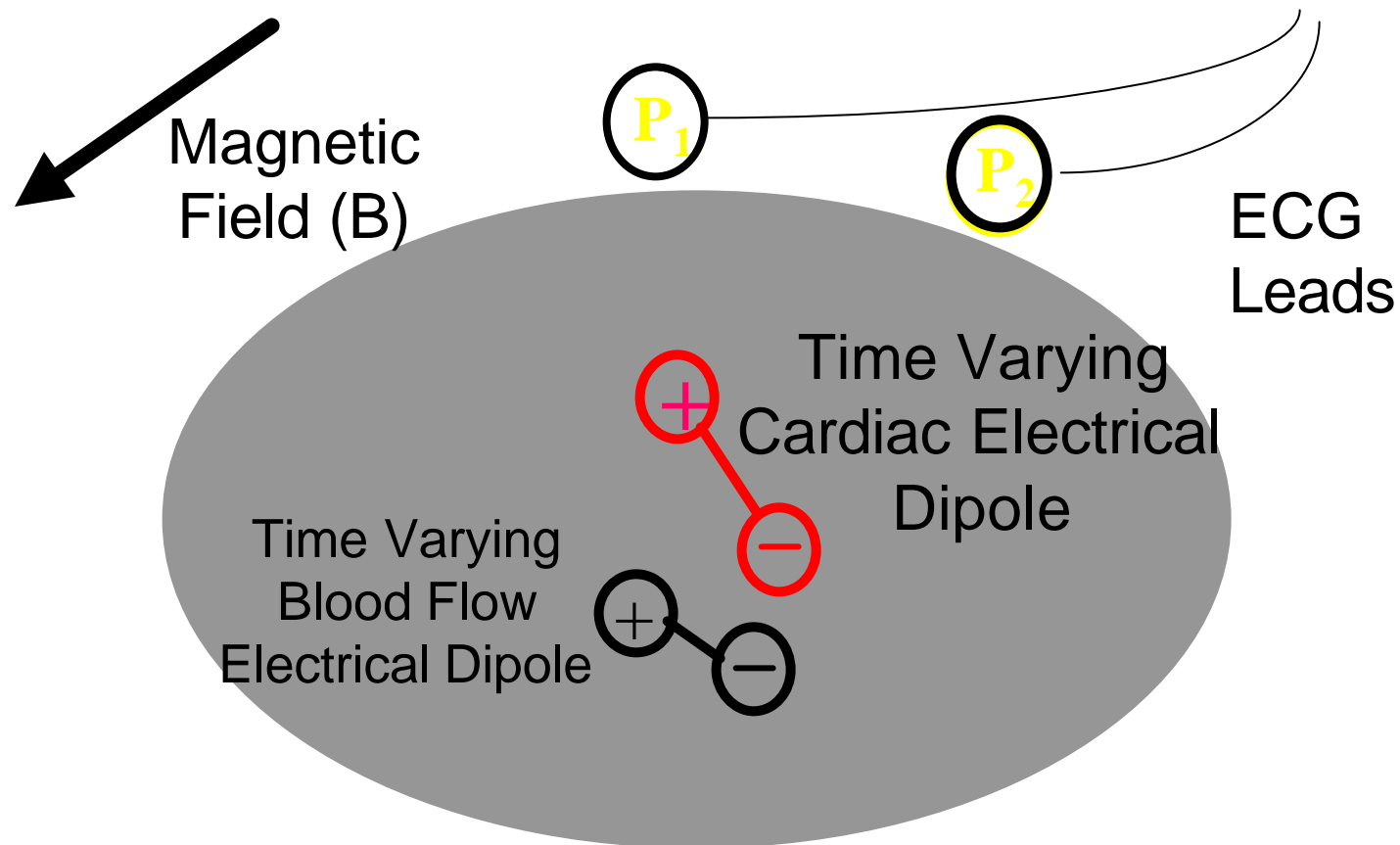
$$E_{p_1} = \frac{m \cos q}{r_1^2}$$



Charged Particles in Blood Flowing through a Magnetic Field Experience a Lorentz Force (F)

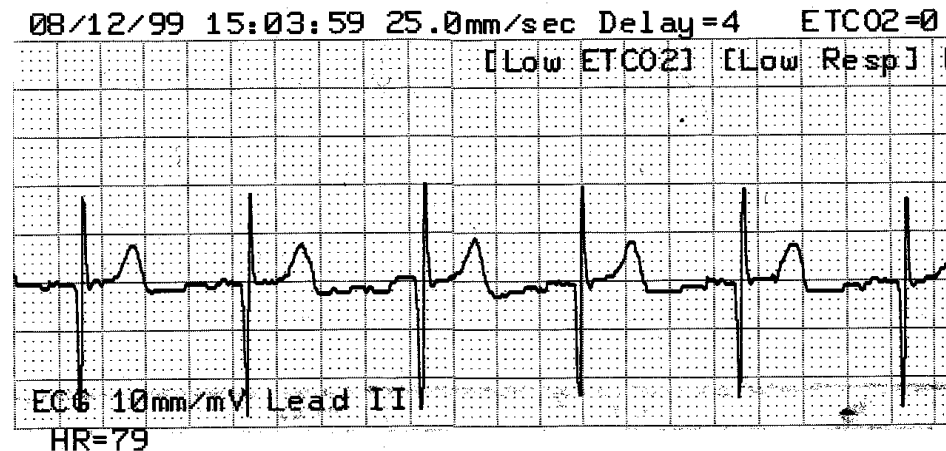


The ECG is Contaminated by a Blood Flow Related Surface Potential in the Magnet

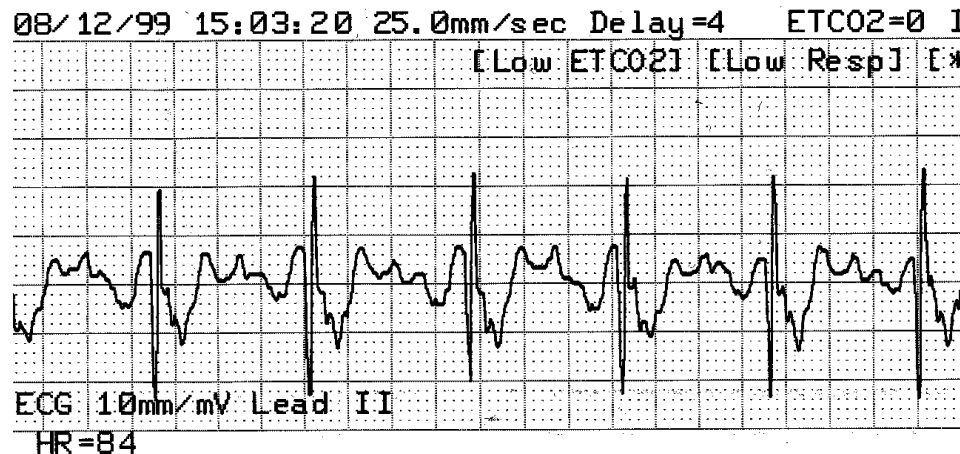


The ECG is Contaminated by a Blood Flow Related Surface Potential in the Magnet

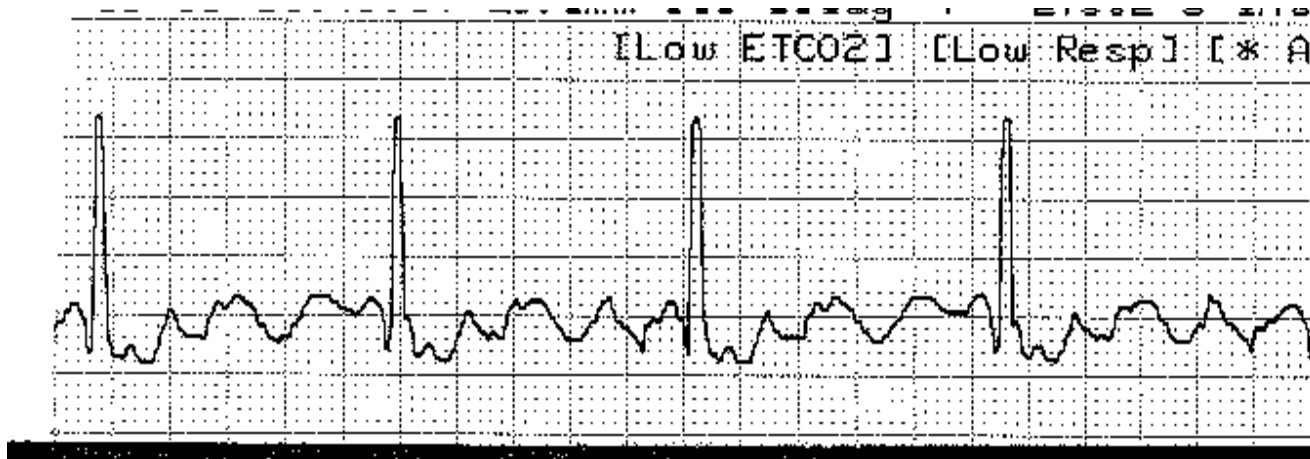
Out of Magnet



In the Magnet



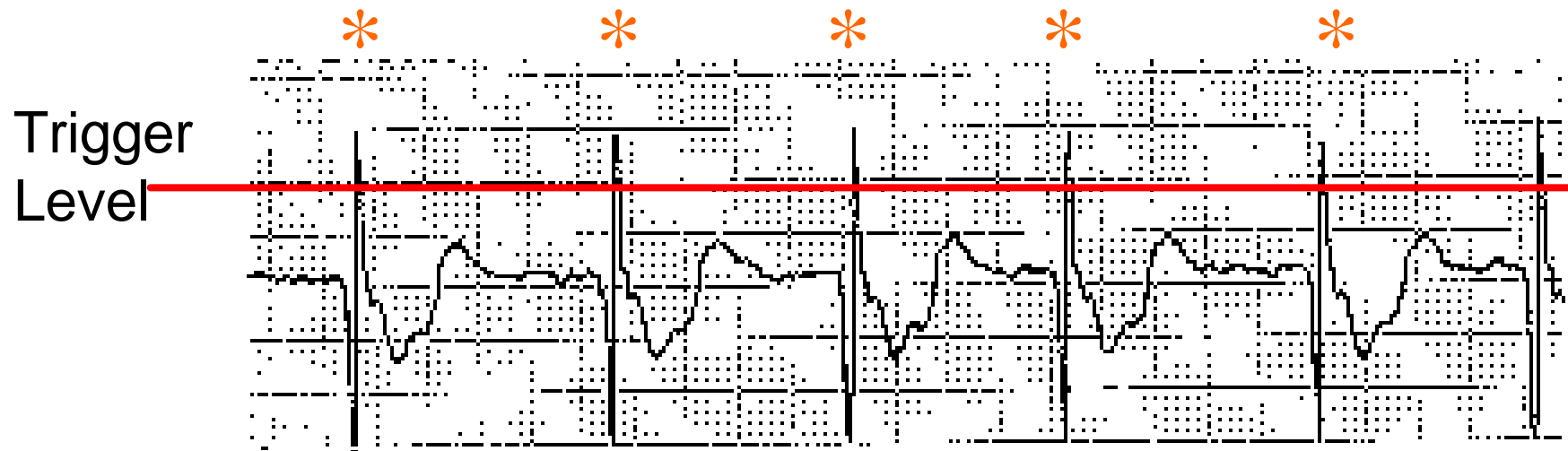
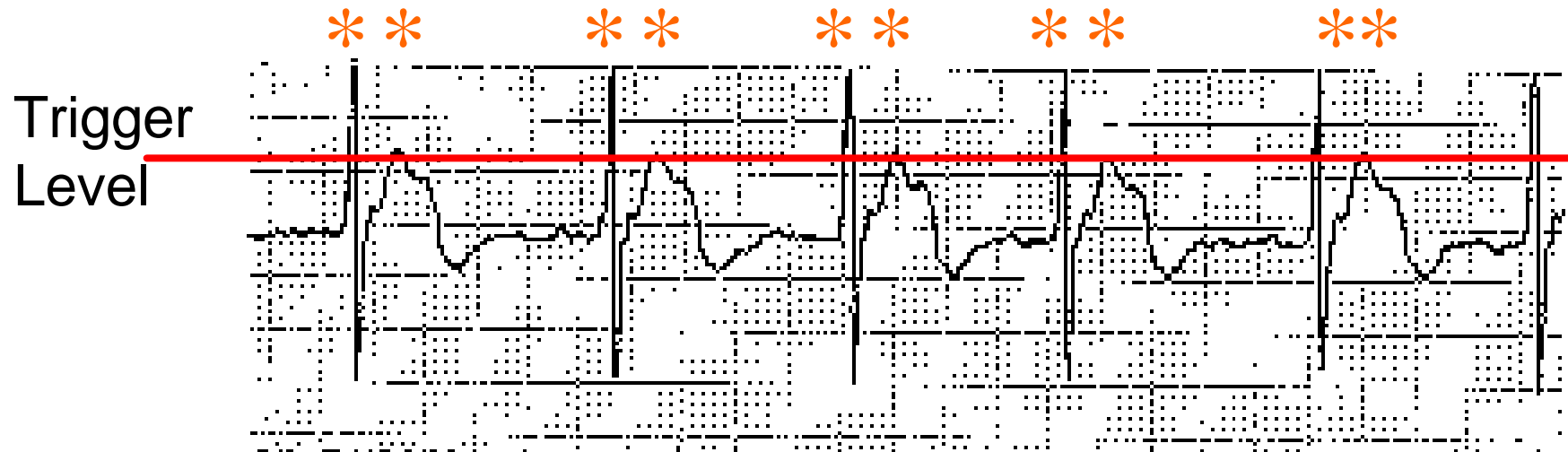
Degradation of ECG Diagnostic Information



- ECG Morphologic Diagnoses
 - ST-T wave abnormalities (*)
 - Q-waves (*)
 - QRS duration (*)
- Arrhythmias
 - Ventricular arrhythmias (ok)
 - Supraventricular arrhythmias (ok)
 - Atrioventricular block (*)

(*) Diagnostic information distorted or lost during MRI

Trouble Shooting: Biphasic QRS

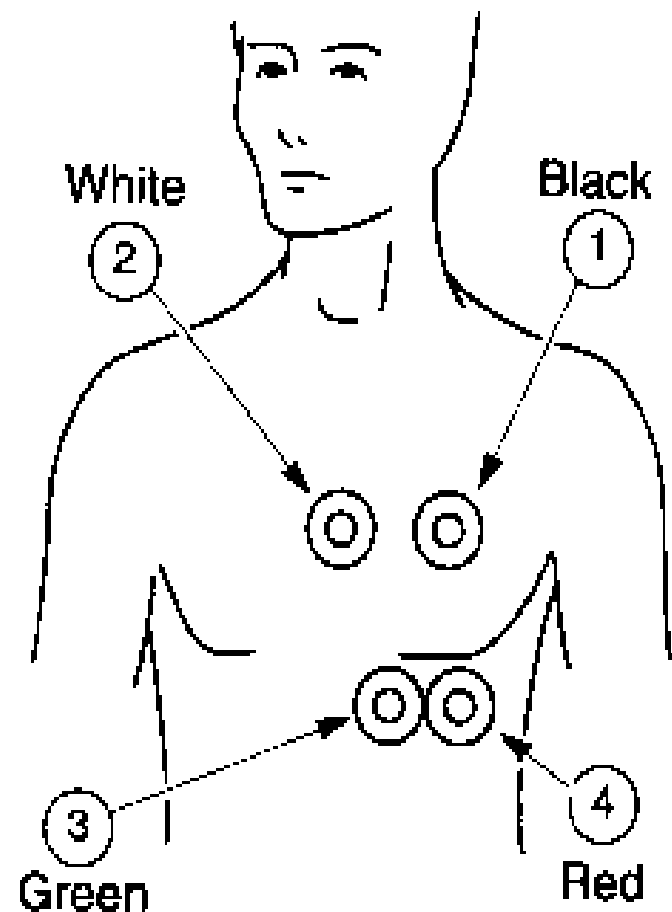


Pointers on Achieving Reliable ECG Gating

- Shaving - site preference
- Skin preparation - NuPrep[©] or other slightly abrasive cleaner
- Check leads with impedance meter (outside of room)
- Consistent prep and lead placement

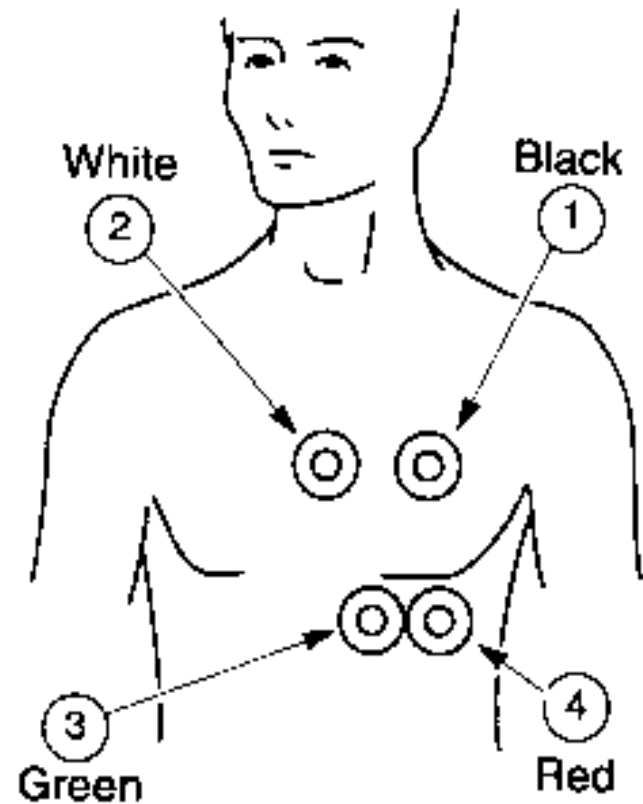
Placement of ECG Leads and Skin Prep

- Modified 4-limb lead configuration (see figure)
- For 3-lead systems, we use positions 1, 2, and 4
- Skin Prep is essential:
 - Nu-Prep skin abrasive
D.O. Weaver & Co.
- ECG pads can make a difference:
 - Vermed Radio-Translucent
V Lead Electrodes
Vermont Medical, Inc.



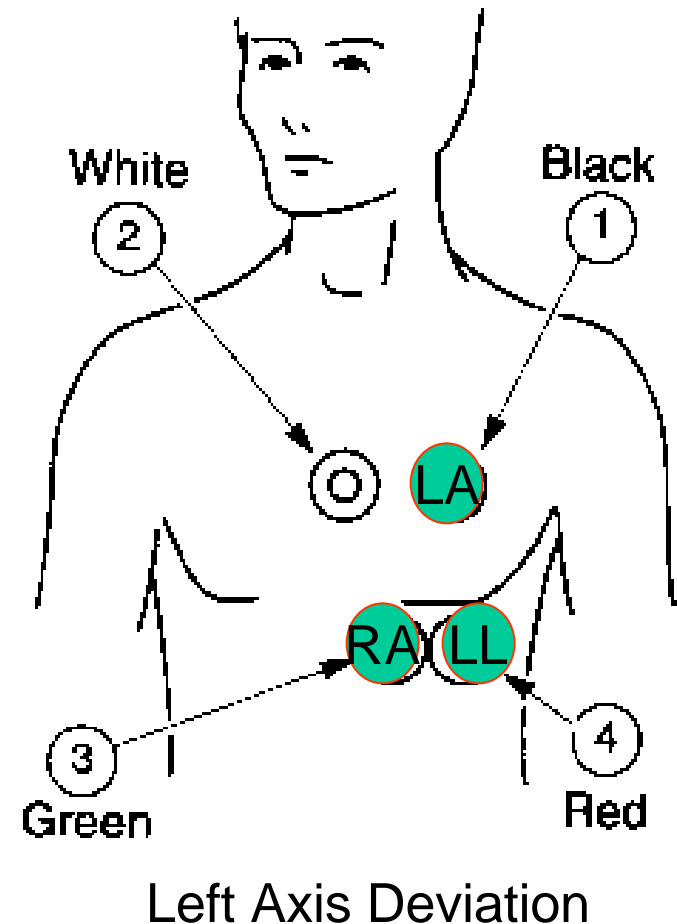
Placement of ECG Leads

- ECG lead placement is modified from the standard configuration to minimize artifacts
- QRS axis is important for QRS amplitude
- High QRS amplitude = gating success

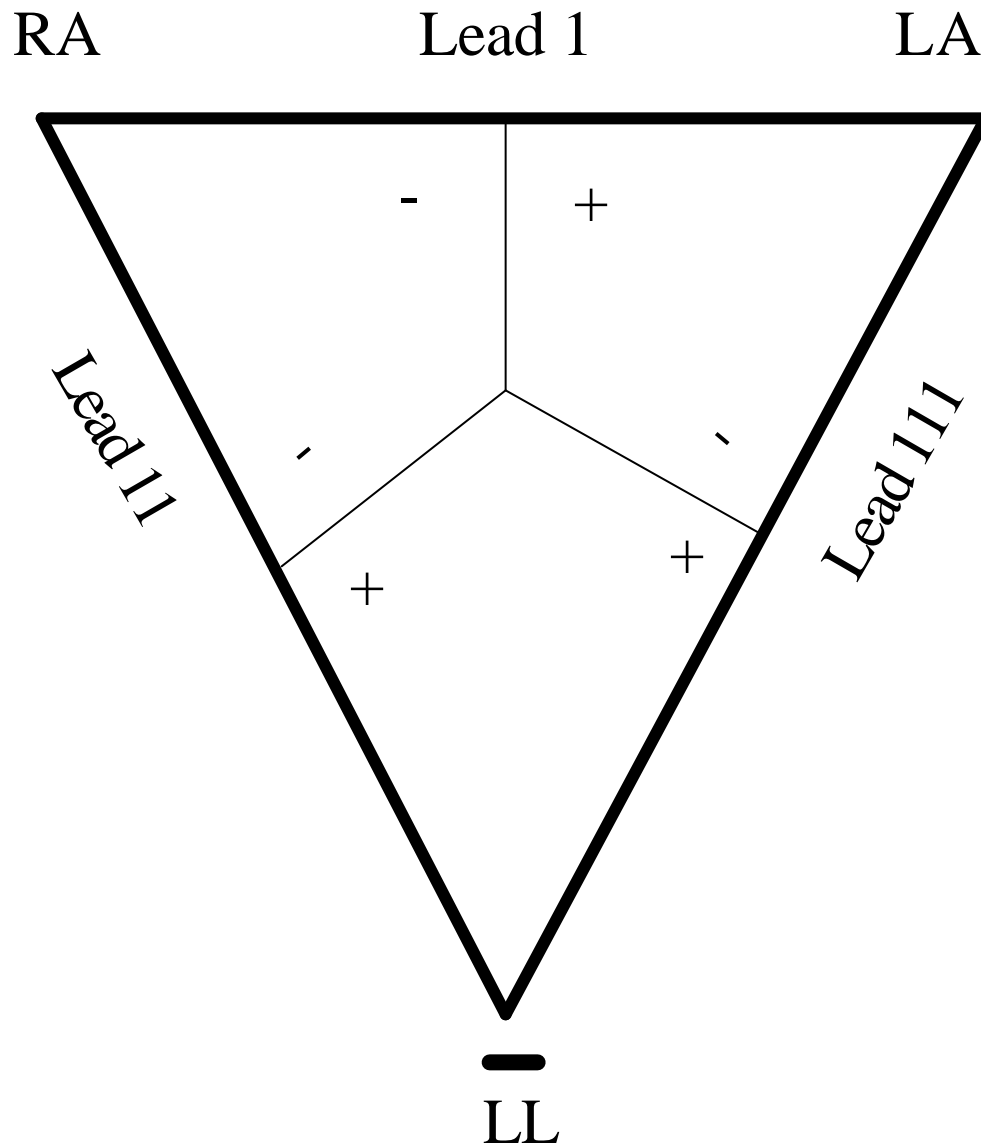


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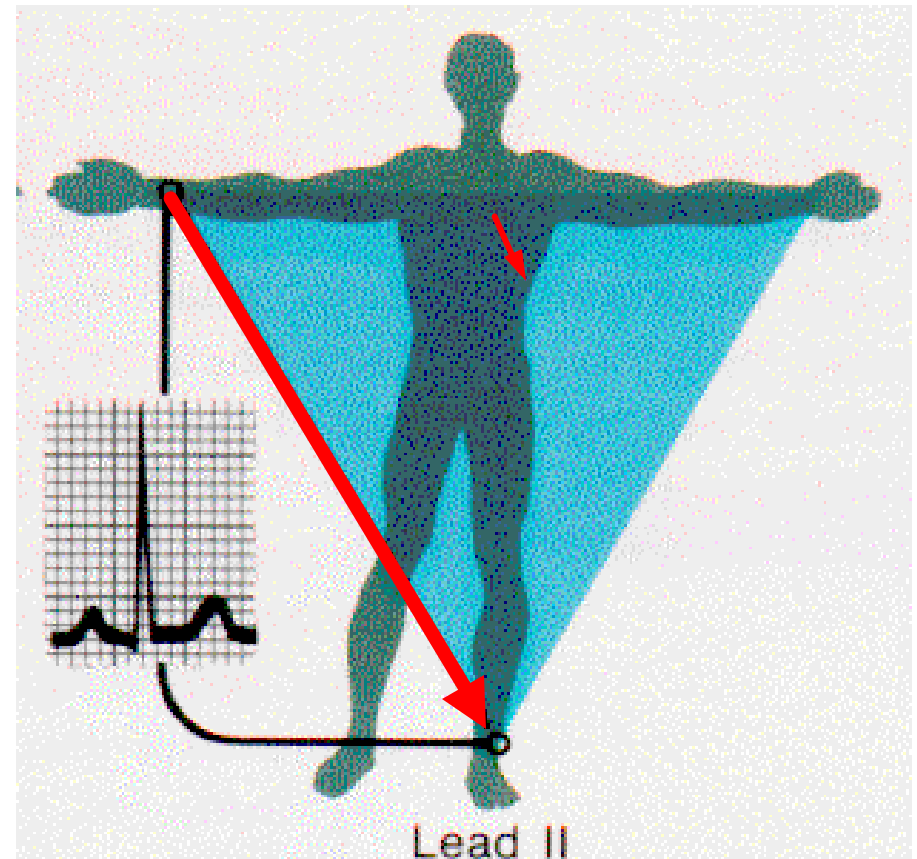
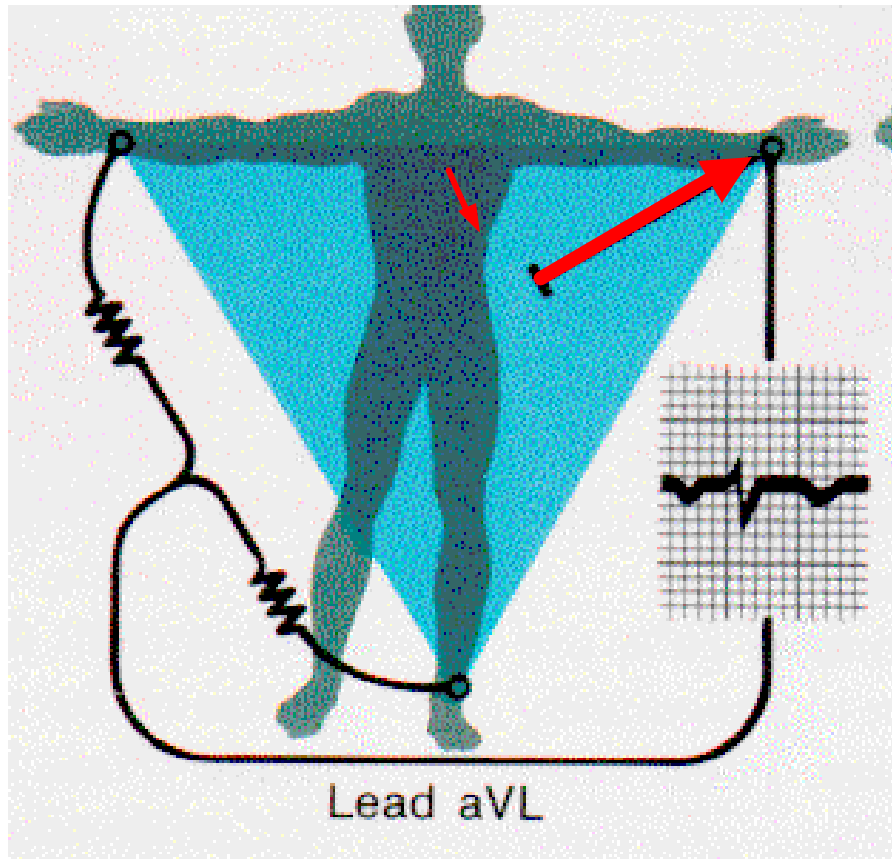


Einthoven's Triangle



The magnitude and configuration of the individual waves of the ECG vary with the location of the electrodes

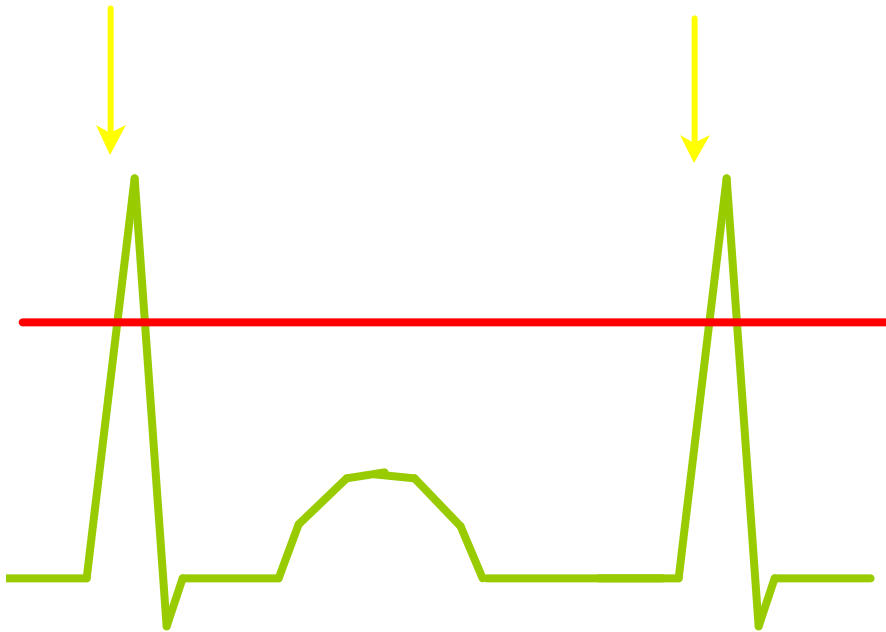
Trouble Shooting: ECG amplitude



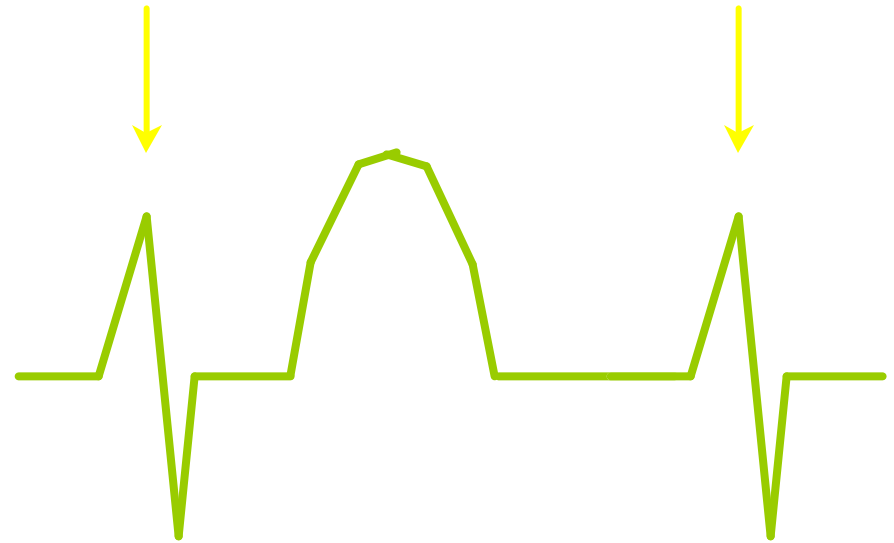
S. Scheidt. Basic Electrocardiography: Leads, Axes, Arrhythmias. CIBA Clinical Symposia 35(2): 1983

Know Your ECG Gating Algorithms

Threshold detection of
QRS Complex



Peak/slope detection of
QRS complex



Safety Concerns with ECG and Monitoring Equipment

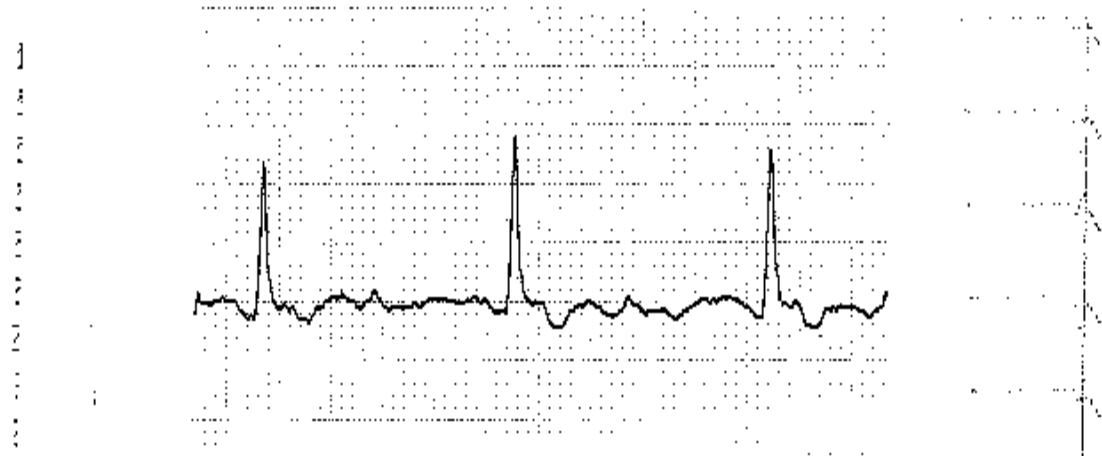
- Coiled wires, can = patient burns
- ECG patches do NOT heat up significantly

FDA: Maude search for safety issues with monitoring equipment (USA)

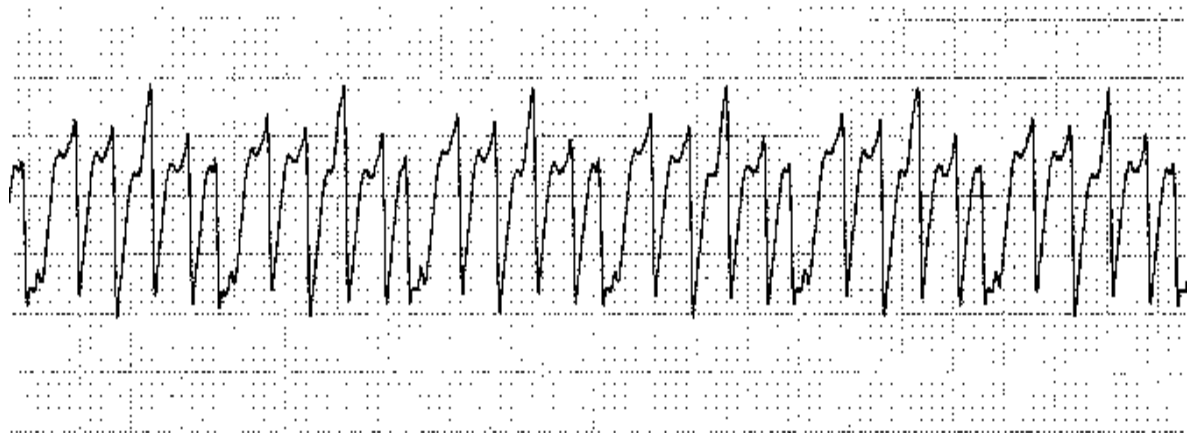
<http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/search.cfm>

Gradient Interference on the ECG

Pre-stress

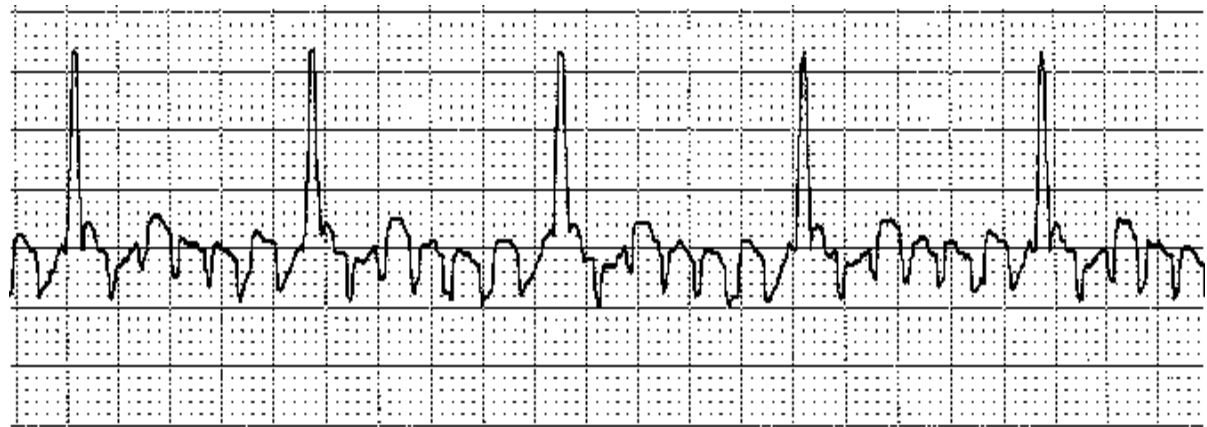


During dipyridamole
perfusion imaging
at peak stress

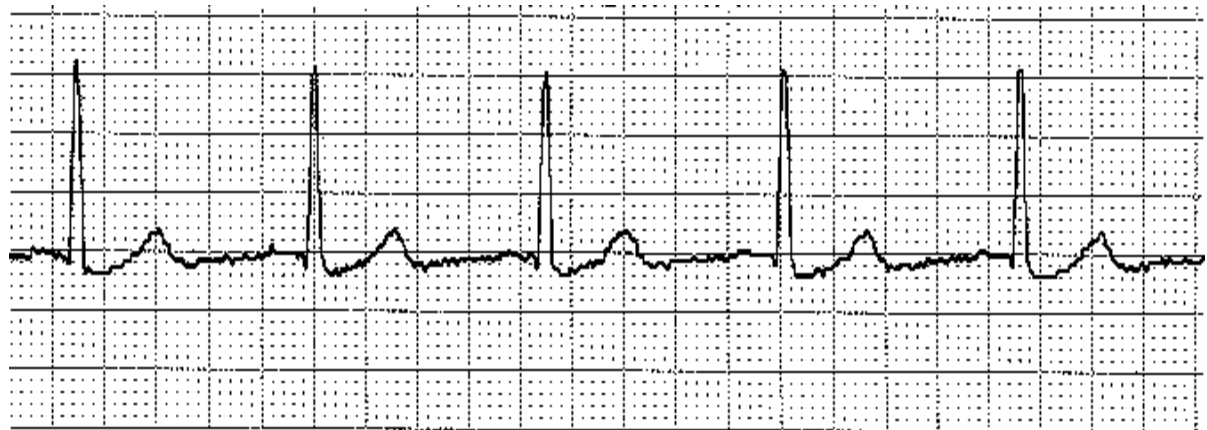


Gradient Interference on the ECG

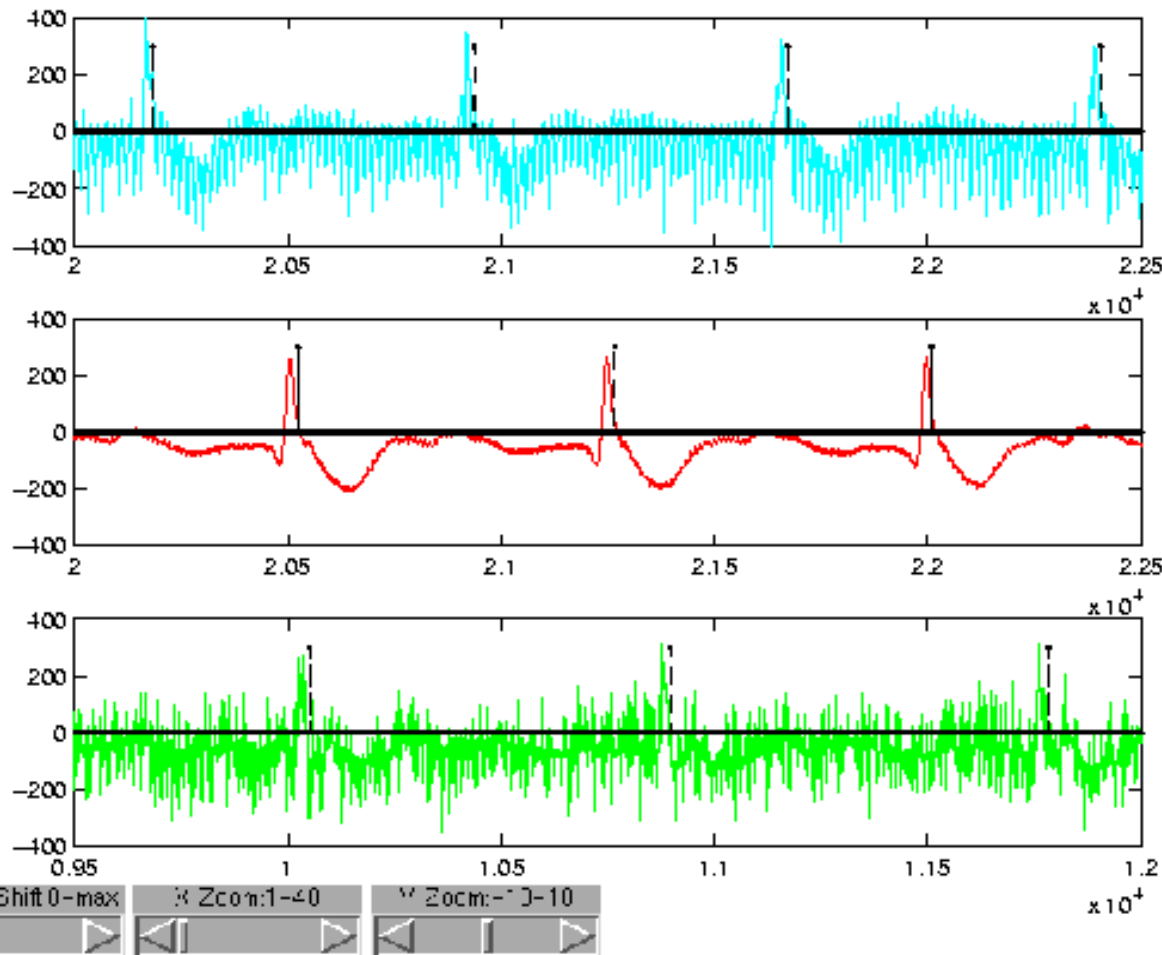
3-D Navigator



Out of Magnet



ECG Filtering and Processing

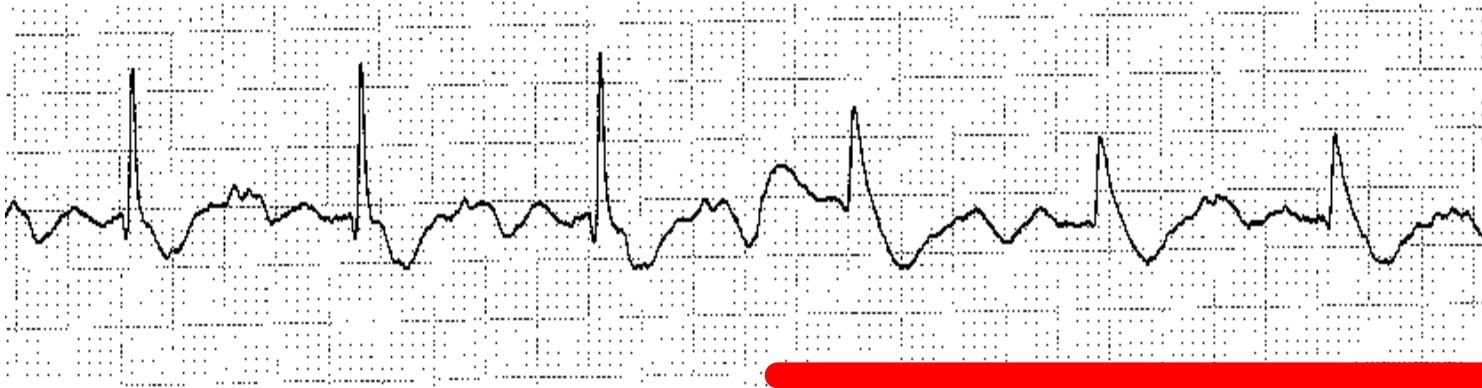


***Standard
Leads***

***Fiber Optic
ECG***

***High
Impedance
Leads***

Trouble Shooting: Adaptive Filtering During MRI Acquisition



 Acquisition

Continuous ECG rhythm strip during hybrid
GRE cine acquisition with echo-train readout

Acknowledgements

3 Tesla Core Facility

NHLBI

NMR F

Duke List Serve for MR Technologists

GE Medical Systems

Avotec, Inc.

Medrad, Inc.

Berlex Laboratories

ACR Glossary of MR Terminology